

Mosquito species biodiversity in Phytotelmata from Western Ghats, south India

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Abstract

The Western Ghats hill ranges in Indian peninsula are one of the 25 hot spots in the world. Western Ghats hill ranges are rich with fauna and flora. This study was carried out in 11 hill ranges of Western Ghats falling in three States of South India, by the Centre for Research in Medical Entomology (CRME) Madurai, during July 2010 to October 2013. Altitude of the hill ranges span between 300m-2300m which receives rains from both southwest and northeast monsoons. Major emphasis was given to survey immatures in Phytotelmata habitats. 124 mosquito species were recorded belonging to 30 genera and 24 subgenera in 11 Phytotelmata habitats. Among these 10 Anopheles and 114 Culicine species were recorded. One malaria vector (*Anopheles culicifacies*), two JE vectors (*Culex pseudovishnui*, *Cx. whitmorei*) and two dengue/chikungunya vectors (*Stegomyia aegypti*, *St. albopicta*) were recorded.

Keywords: Phytotelmata, Western Ghats, tree holes, mosquitoes.

Introduction

A term Phytotelmata ('plant-waters') was coined by Varga (1928) to describe bodies of water impounded by plants. According to Fish (1983) over 1500 different plant species from at least 26 families have been reported to impound water. Leaf axils seem to be the most common type of Phytotelmata (Greeney, 2001), with the Bromeliaceae alone believed to have more than 1000 species capable of impounding water (Frank, 1983). Phytotelmata can be seen as aquatic microcosms since, despite the very small volume of rainwater collected in them, micro-communities have been found there which, relative to the size of the habitat have a very diverse range of taxa, which survive and interact as small ecosystems. Around 470 species of aquatic animals have been recorded so far in these bromeliad tanks. The literature on mosquitoes inhabiting phytotelmata is relatively extensive, particularly due to bromeliad-breeding species and their public health significance in tropical regions (Olano et al. 1997; Forattini et al. 1998; Cunha et al. 2002). Christopher (1933) and Barraud (1934) in Fauna of British India (Family Culicidae), identified more than 22 phytotelmata habitats and recorded 22

mosquito species. Two-letter generic and three-letter sub generic abbreviations used in the paper were adopted from Reinert (1975).

Material and Methods

Study area

Eleven hill ranges were surveyed in Western Ghats, comprising three states viz; Agastya hills, Andipatti hills, Varusanad hills, Palani hills, Anamalai hills, Nilgiri hills (Tamil Nadu), Munnar, Malappuram, Parambikulam and Silent valley (Kerala), Coorg (Karnataka), from 2010 to 2013. Altitude of the hill ranges ranged between 300m-2300m which receives rain from both southwest and northeast monsoons. Major emphasis was given to surveys, for the collection of larval and pupal stages of mosquitoes which breed in phytotelmata habitats such as tree hole, log hole, bamboo stump, bamboo sheath, fallen tree, papaya stump, reed stumps, leaf axils, banana stump, mushroom, pitcher plant. Identification of species was based mainly on adult characters, however larval and pupal chaetotaxy were also examined wherever necessary (Tyagi et al. 2012, 2014).

Results and Discussion

A total of 124 mosquito species were recorded from 36044 specimens belonging to 30 genera and 24 subgenera in 11 Phytotelmata habitats (Table 1). Tree holes were the most favorable habitat, which contributed 99 species from 21440 specimens followed by bamboo stumps 73 species from 11753 specimens, log hole 20 species from 637 specimens, leaf axils 10 species from 561 specimens etc., (Fig. 1). Among these 10 Anopheles and 114 Culicine species were recorded. One malaria vector (*Anopheles culicifacies*) was collected from typical wide open hole (25-50 cm. diameter) near the base of felled tree trunks (fallen tree), two Japanese encephalitis vectors (*Culex pseudovishnui*, *Cx. whitmorei*) were recorded from tree holes and bamboo stumps and two dengue/chikungunya vectors (*Stegomyia aegypti*, *St. albopicta*) were recorded from tree holes, bamboo stumps, reed stumps and log holes. *Stegomyia albopicta* (5070) was numerically the most abundant species and also recorded from six habitats followed by *Tripteroides araneoides* (3247), *Dendroskusea reginae* (2623), *Orthopodomyia flavithorax* (2280) and *Armigeres subalbatus* (2268).

Notes on few important Phytotelmata habitats

Tree hole and Log hole

Tree holes are the primary breeding sites for multiple disease vectors, most frequently mosquitoes (Yanoviak 2001). No study has explicitly examined tree hole occurrence according to specific genus or species of tree, tree-level factors such as diameter at breast height and stand-level characteristic such as basal area. Mattingly (1969) classified tree holes according to their means of saturation into two distinct groups. One group of tree holes are filled constantly with water drawn up by the roots of the tree, and other group is dependent on rainwater. Because the tree hole community is based on the leaves that fall into them, these communities are often called detritus-based communities. In Western Ghats maximum number of mosquito species (99) were recorded in tree holes (Figs. 2, 3).

However, very few studies have addressed water chemistry factors that are potentially limited to tree hole insect populations (Petersen and Chapman, 1969;

Mitchell and Rockett, 1981; Beier et al. 1983; Paradise, 1979). Mosquitoes inhabiting tree holes show increased mortality, decreased growth rates and smaller size when stem flow contains high concentrations of hydrogen ions (Carpenter, 1982). Nutrients, including sulfates and nitrates, can also adversely affect mosquito populations in tree holes, in part by changing bacterial population dynamics (Walker et al. 1991). Most of these arthropods are obligate tree hole breeders, although they also utilize other small bodies of standing water in man-made containers that simulate tree holes (Laird, 1988). The size and location of the tree hole may be important in determining presence/absence of any particular species.

Bamboo stumps

Different types of bamboo are found in the rich and biodiverse regions of Western Ghats. Water tight containers are formed by the wood-chewing beetles in the internodes of the bamboo stem. Once the beetles get inside of the internodes they lay their eggs. When the eggs hatch, the larvae of beetles chews on the plant tissue and make their way out of the bamboo internodes leaving a bigger hole. Once these holes have been formed a phytotelmata habitat gets created filled with water ready for different species to inhabit it. During present investigations, about 73 mosquito species were recorded in these habitats (Figs. 4, 5).

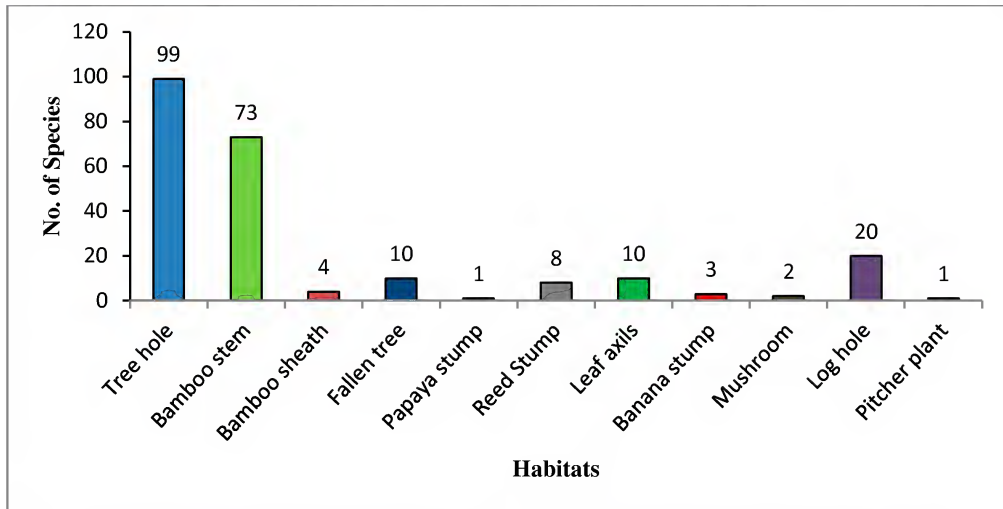
Plant leaf axils

Leaf axil habitats are formed when water fills up in the axil of leaves. Axil habitats are small and hold a simple aquatic community comprising mainly of filter-feeders. Mosquitoes breed in leaf axils of many plants like Plantain, Pineapple, Pandanus, Nipa, Taro, and Colocasia. In Western Ghats 10 mosquito species were recorded from leaf axils (Figs. 6, 7).

Pitcher plants

Pitcher plants with their water tight containers act as traps for insects and other small creatures. The detritus created by dead decomposing insects inside the pitcher creates an organically rich aquatic environment for the pitcher tank biotic community. A total of fifteen mosquito species representing three genera *Aedes*, *Wyeomyia* and *Toxorhynchites*

Figure 1. Habitat wise distribution of mosquito species in Western Ghats



Figs. 2, 3: 2. Tree hole; 3. Log hole



Figs. 4, 5: 4. Bamboo stump; 5. Bamboo fence

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Figs. 6,7: 6. *Colocasia*; 7. Pineapple



Figs. 8, 9: *Nepenthes* sp.

Table 1. Mosquito species recorded (through Immature collection) from phytotelmata habitats in Western Ghats

Sl. No.	Species/Breeding habitat	Habitat											No. of Specimen
		Tree hole	Bamboo stump	Bamboo sheath	Fallen tree	Papaya stump	Reed stump	Leaf axils	Banana stump	Mushroom	Log hole	Pitcher plant	
1	Anopheles (Anopheles) aitkenii	5											5
2	Anopheles (Anopheles) culiciformis	2											2
3	Anopheles (Anopheles) insulaeflorum	3											3
4	Anopheles (Anopheles) interruptus	28											28
5	Anopheles (Anopheles) sintoni	148											148
6	Anopheles (Cellia) culicifacies				99								99
7	Anopheles (Cellia) elegans	8											8
8	Anopheles (Cellia) mirans	63	5								3		71
9	Anopheles (Cellia) jeyporiensis	7											7
10	Anopheles (Cellia) maculatus	3											3
11	Aedimorphus alboscutellatus		1										1
12	Aedimorphus caecus	21	54								9		84
13	Armigeres (Armigeres) durhami		350			36							386

14	Armigeres (Armigeres) joloensis	4										4	
15	Armigeres (Armigeres) subalbatus	1535	417				73	30	119			94	2268
16	Armigeres (Leicesteria) digitatus		39										39
17	Armigeres (Leicesteria) flavus	19	956	28			96						1099
18	Armigeres (Leicesteria) longipalpis		3										3
19	Armigeres (Leicesteria) magnus		22										22
20	Armigeres (Leicesteria) omissus	4	76										80
21	Bruceharrisonius aureostriatus	347	78		6								431
22	Bruceharrisonius greenii	5						28					33
23	Christophersiomia annulostris	344	1								13		358
24	Christophersiomia gombakensis	1											1
25	Christophersiomia thomsoni	5											5
26	Collessius (Alloeomyia) pseudotaeniatus	166	3								29		198
27	Culex (Culex) mimiticus	41											41
28	Culex (Culex) mimulus		3										3
29	Culex (Culex) niligricus	5									2		7
30	Culex (Culex) pseudovishnui	3											3
31	Culex (Culex) whitmorei		1										1
32	Culex (Culiciomyia) bailyi	2											2
33	Culex (Culiciomyia) fragilis	13	10										23
34	Culex (Culiciomyia) nigropunctatus		3										3
35	Culex (Culiciomyia) pallidothorax	100	106		3				5		6		220
36	Culex (Culiciomyia) spathifurca	171											171
37	Culex (Eumelanomyia) brevipalpis	864	29										893
38	Culex (Eumelanomyia) khazani	236	1										237
39	Culex (Eumelanomyia) malayi		3										3
40	Culex (Lopoceraomyia) bengalensis	1	3										4
41	Culex (Lopoceraomyia) flavicornis	120											120
42	Culex (Lopoceraomyia) lasiopalpis	1											1
43	Culex (Lopoceraomyia) mammilifer	99	2										101
44	Culex (Lopoceraomyia) minor	303	298	2				8			134		745
45	Culex (Lopoceraomyia) minutissimus	10											10
46	Culex (Lopoceraomyia) peytoni	1											1
47	Culex (Lopoceraomyia) pholeter	2	1										3
48	Culex (Lopoceraomyia) raghavanii										32		32
49	Culex (Lopoceraomyia) uniformis	3471	976		78		15				204		4744
50	Danielsia albotaeniata	11	5										16
51	Dendroskusea kanarensis	6											6
52	Dendroskusea reginae	2623											2623
53	Downsiomyia albolateralis	502	151										653
54	Downsiomyia nivea	429	8										437
55	Ficalbia minima	1											1
56	Fredwardsius vittatus	451	10					1					462
57	Heizmannia (Heizmannia) chandi	104	108										212
58	Heizmannia (Heizmannia) greenii	66	21										87
59	Heizmannia (Heizmannia) indica	20	51								8		79

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60	Heizmannia (Heizmannia) metallica	17	25							8		50
61	Heizmannia (Mattinglyia) discrepans	98	168			8						274
62	Hopkinsins (Yamada) albocinctus	2										2
63	Hulecoeteomyia chrysolineata	273	495	13			140	4	68	2		995
64	Hulecoeteomyia pallirostris		1				95					96
65	Hulecoeteomyia harveyi		10									10
66	Kenknightia dissimilis	108										108
67	Lorrainea fumida	3										3
68	Lutzia (Metalutzia) fuscana	68										68
69	Lutzia (Metalutzia) halifaxii	1										1
70	Malaya genurostris						164					164
71	Malaya jacobsoni						65					65
72	Mimomyia (Etorleptimya) luzonensis		1									1
73	Orthopodomyia albipes		18									18
74	Orthopodomyia anopheloides	292	8		2					2		304
75	Orthopodomyia flavithorax	2280										2280
76	Orthopodomyia flavicosta	41										41
77	Phagomyia cacharana	3	1									4
78	Phagomyia cogilli	4	1									5
79	Phagomyia deccana	3										3
80	Phagomyia gubernatoris	44	19									63
81	Phagomyia inquinata	3										3
82	Phagomyia khazani	17										17
83	Phagomyia prominens	20	18									38
84	Rhinoskusea portonovoensis	19										19
85	Scutomyia albolineata	2	3									5
86	Stegomyia (Actinothrix) edwardsi	160										160
87	Stegomyia (Heteraspidion) annandalei	1	13									14
88	Stegomyia (Heteraspidion) craggi	8	16									24
89	Stegomyia (Huangmyia) perplexa		21									21
90	Stegomyia (Stegomyia) aegypti	119	4			1				2		126
91	Stegomyia albopicta	2316	2142		463	3	18			128		5070
92	Stegomyia flavopicta	1										1
93	Stegomyia krombeini	505	40		242					6		793
94	Stegomyia malayensis	30										30
95	Stegomyia mediopunctata		8									8
96	Stegomyia novalbopicta	483	167									650
97	Stegomyia pseudoalbopicta	82	73									155
98	Stegomyia subalbopicta	355	38		2							395
99	Stegomyia w-alba	2	8									10
100	Tewarius agastyai	354	331									685
101	Tewarius reubenae	231										231
102	Toxorhynchites (Toxorhynchites) edwardsi	5										5
103	Toxorhynchites (Toxorhynchites) graveli		3									3
104	Toxorhynchites (Toxorhynchites) kemp		6									6

105	Toxorhynchites (Toxorhynchites) minimus	3	3				1						7
106	Toxorhynchites (Toxorhynchites) splendens	250	265		4			12			6		537
107	Tripteroides (Rachionotomyia) affinis	533	93								25		651
108	Tripteroides (Rachionotomyia) aranoidea	150	2951				130				16		3247
109	Tripteroides (Rachionotomyia) serratus	4											4
110	Tripteroides (Tripteroides) indicus	11											11
111	Tripteroides (Tripteroides) tarsalis		13										13
112	Uranotaenia (Pseudoficalbia) bicolor	35	950										985
113	Uranotaenia (Pseudoficalbia) lutescens	1	22										23
114	Uranotaenia (Pseudoficalbia) novobscura	52	4								2		58
115	Uranotaenia (Pseudoficalbia) obscura	5			3					54			62
116	Uranotaenia (Pseudoficalbia) ohamai	3											3
117	Uranotaenia (Pseudoficalbia) recondita	50	6	1									57
118	Uranotaenia (Pseudoficalbia) stricklandi	4	1										5
119	Uranotaenia (Pseudoficalbia) luteola		5										5
120	Uranotaenia (Uranotaenia) annandalei	4											4
121	Uranotaenia (Uranotaenia) campestris	4											4
122	Uranotaenia (Uranotaenia) edwardsi		6										6
123	Uranotaenia (Uranotaenia) orientalis		1										1
124	Verrallina (Verrallina) dux	7											7
	No. of species recorded in habitats	99	73	4	10	1	8	10	3	2	20	1	

were recorded from *Sarracenia* sp. The mosquito *Wyeomyia smithii* strictly depends on *Sarracenia purpurea* to complete its larval development (Bradshaw, 1983). In the food web of the pitcher, *Wyeomyia* serves as the top predator; the population size of *Wyeomyia* is negatively correlated with inquilin diversity (Buckley et al. 2003). Nine mosquito species were recorded from India, but in Western Ghats we recorded only one species (*Ar. subalbatus*) in this habitat (Figs.8, 9).

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